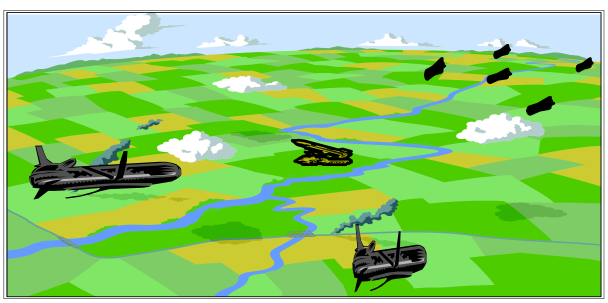
<u>Dynamics and Control</u>

Cooperative Behavior and Control of Autonomous Air Vehicles

Overview

Smart munitions and Uninhabited Combat Air Vehicles (UCAV's) are currently in the technology demonstration phase within the DoD. These vehicles are able to operate autonomously with the ability to search for, identify and make decisions on whether or not to engage a target. Significant improvements in mission effectiveness could be realized if the autonomous air vehicles were to cooperate in terms of information sharing and coordinated target attack. Implementation schemes must take into account realistic false alarm rates, vehicle reliability rates, and target kill probabilities amongst other factors. Further, any cooperative behavior and control algorithm must be consistent with the implementation constraints of the intended air vehicle.



For the UCAV problem, the areas of optimal path planning and coordinated rendezvous are currently being addressed. To piecewise characterize a more complex problem, fundamental parameterized problems in threat avoidance are being investigated. The possibility of a suboptimal deterministic solution to the path planning problem within a quantifiable measure of the optimal path is also being explored. A deterministic solution may prove to be more reliable and/or computationally tractable than solving an on-line optimization problem.

Approach

Research for the autonomous munition problem centers around a rule based approach where the decision parameters are chosen ahead of time to optimize the expected mission effectiveness for multi-munition/multi-target scenarios. A Response Surface Methodology is being investigated to define the parametric surface, and optimization methods will then be applied to determine appropriate operating points for specified scenarios. Because they are rule based, the algorithms should be easy and inexpensive to implement. A candidate wide area search munition concept is being used to validate and evaluate this approach.

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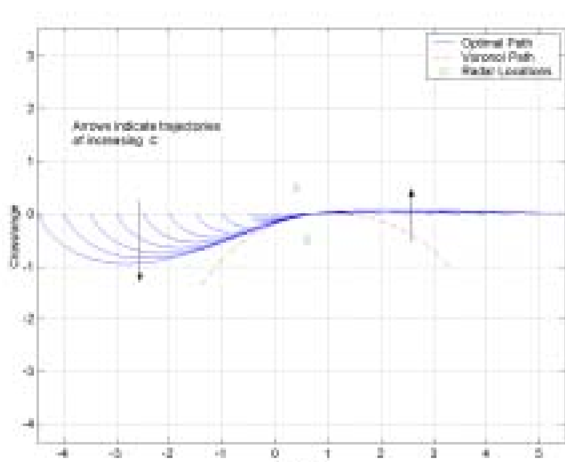
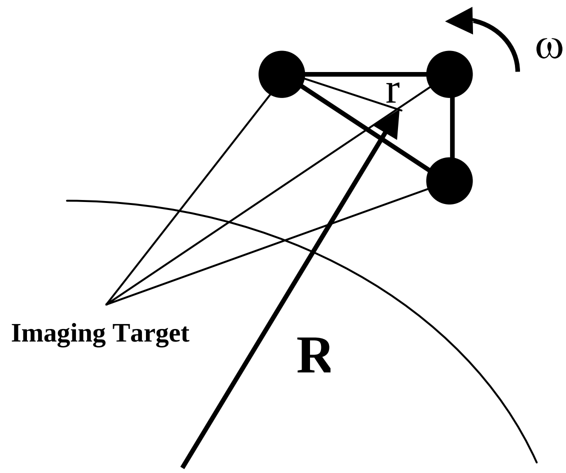


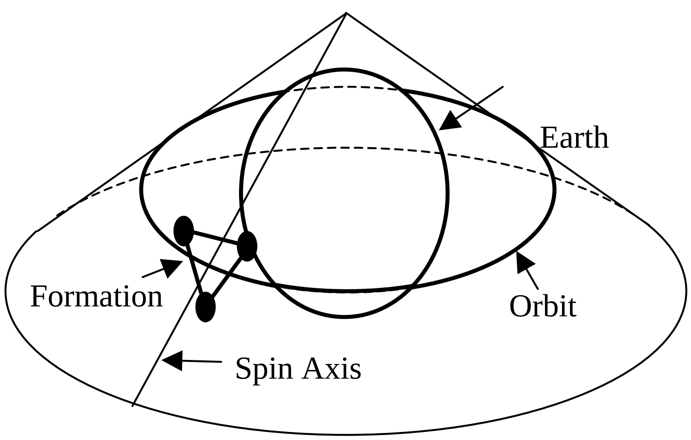
<u>Dynamics and Control</u>

Formation Flying with Tethered Satellites

Motivation

A formation of satellites has great potential to enhance surveillance and imaging of earth objects. Significant efforts have been directed at the guidance and control of these satellite clusters using reaction thrusters. This research effort considers an alternate approach of tethering the subsatellites together as shown at right in order to eliminate stationkeeping maneuvers to maintain proximity.





Formation Design

To maintain the shape of the planar formation and keep the tethers in tension, the system rotates along the axis of the maximum moment of inertia of the system. Changing the orientation of the formation requires significant time and energy, so the concept proposed makes use of the conical Likins-Pringle relative equilibrium. The natural dynamics of this design keeps the spin axis of the formation roughly pointed toward the Earth. Current efforts are investigating the stability of this design with flexible tether dynamics.

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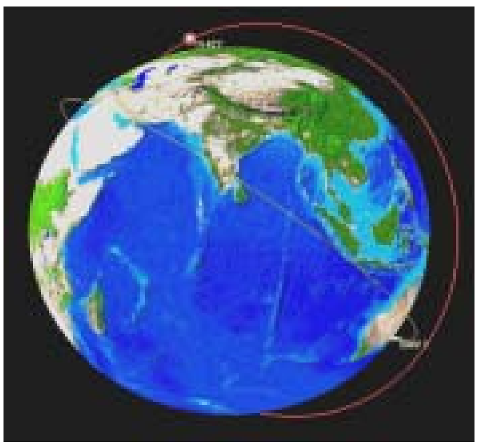
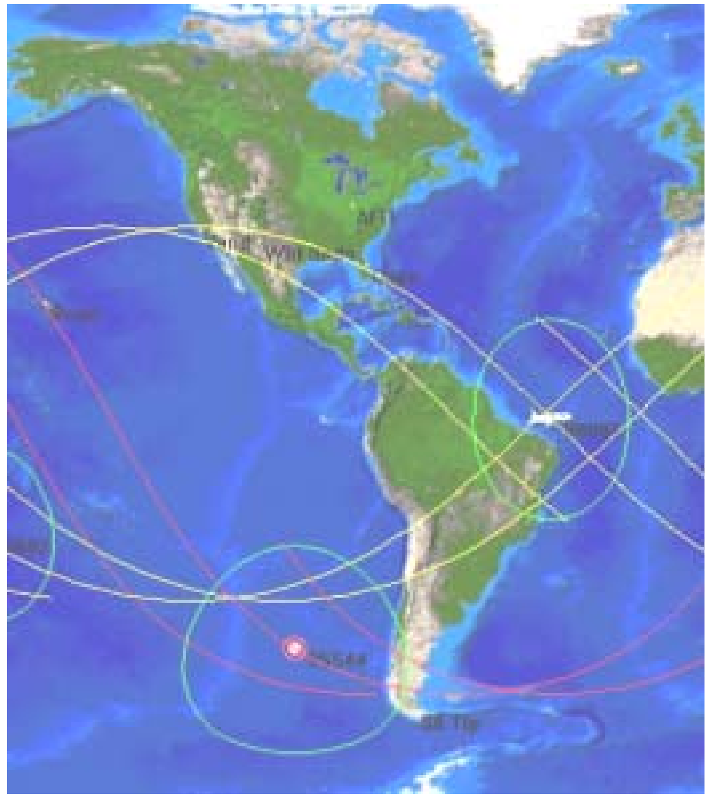
Dynamics and Control

Mission Planning for the Space Maneuver Vehicle

Research Highlights

- Accurate mission planning with a user-friendly interface
- Utilize the approximately 10,000 ft/sec maneuver capability
- Serves as a test bed for development and evaluation of mission strategies and discussion





Recent Findings

The current program has a baseline capability that includes generic launch, orbit to ground, orbit to orbit, and reentry planning capabilities. Extending the software to include possible acts of an unfriendly nature is under consideration. While a maneuver capability of 10,000 ft/sec is almost unheard of in space systems, it is still a challenge to use it wisely, and to not just do something spectacular once.

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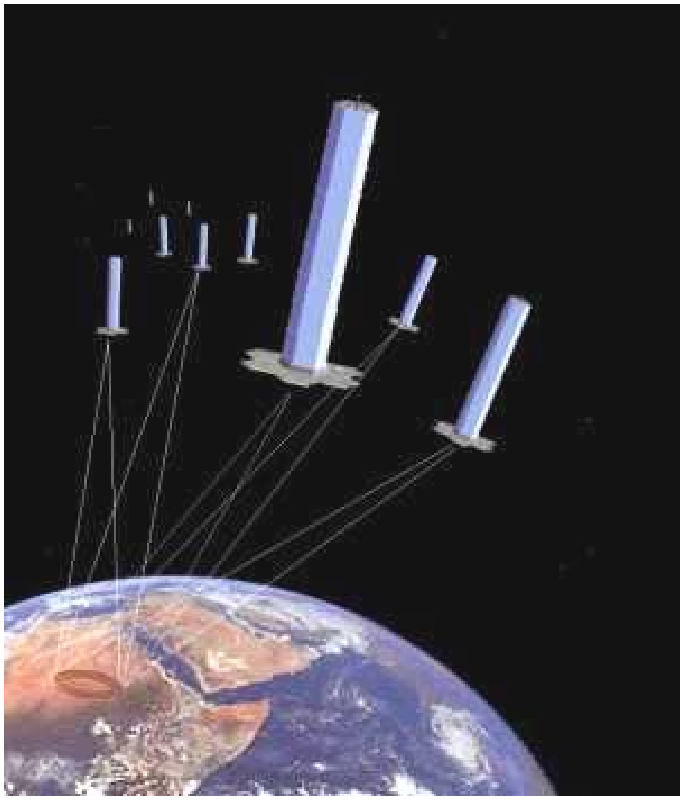
<u>Dynamics and Control</u>

Satellite Cluster Dynamics, Navigation, and Control

The use of satellite clusters for military missions will require formation flight in orbit to unprecedented accuracy. The individual satellites may need to know their relative positions to centimeter accuracy, and function for years on a very limited maneuver budget. This is a critical challenge to dynamical modeling, navigation, and control.

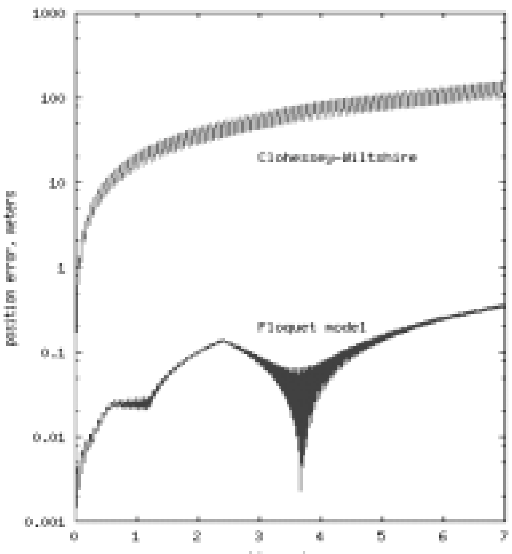


Research Highlights

- A new solution to relative satellite motion includes most perturbing forces.
- Relative navigation using clock synchronization gives the required accuracy.
- Most other dynamically significant forces can be included in the system model.

Recent Findings

The use of Floquet theory for the relative motion model has made it possible to include vastly more dynamics in the “solved” part of the problem, including the critical J2 earth oblateness term. The dynamics can be further extended to account for all natural perturbing forces, making it feasible for the controller to ignore benign dynamical effects. Navigation simulations hold the promise that clock synchronization signals will make it possible to do relative navigation to the required accuracy.



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